Undersea Exploration of Polar Environments (0 FTE; + $10M)

Goal: Better definition of the abiotic and biotic resources of the polar seas and of the controlling physical and biogeochemical processes affecting those resources.

Background/Scope: The Arctic Ocean and the Southern Ocean, i.e., the polar seas, need to be explored to better define their resources, governing processes, and roles in global change. This includes the connecting oceans (e.g., Bering, Chukchi, Beaufort, etc.) and basins and other features. For example, the fishery resources of the Bering Sea are unmatched–the high productivity of the Bering Sea which leads to the large biomass of birds, mammals and fishes has long been an ecological enigma. The Bering Sea supports over 50 commercially important species and at least 50 species of marine mammals. It is unmatched in terms of commercial value of the fishery resources.

Another example of the biological importance of the polar areas relate to krill. Krill, small shrimp-like crustaceans, occur in the frigid Antarctic waters and are a keystone prey species. As a food supply, they support animals from whales, seabirds, fishes and squids, to seals and penguins. Krill have shown a general decline in reproductive success since 1984. In a NMFS-supported study, low temperatures and extensive winter sea-ice development over a two year period were found to favor krill, while warmer temperatures and limited sea-ice development favored salps. Salps not only compete with krill for food, but also form an ecological 'dead end' in that they provide comparatively little food value for Antarctic predators.

Since global change under scenarios of greenhouse warming are forecast by OAR to affect the polar regions, particularly the Arctic, more so than the mid-latitudes, there is concern over the biological susceptibility of temperature change and increased ultraviolet exposure of the base of the food web. This could lead to indirect effects such as decreases in the immune systems of innate ocean biota, to effects on the bioavailability of contaminants in these regions, to changes in the species that comprise the food web. On the abiotic side, it could also lead to unstable gas hydrates which would cause an increase in the input of methane into the atmosphere–giving rise to a positive feedback loop in the global warming process. A molecule of methane is 20-times more effective as a greenhouse gas when compared with one molecule of carbon dioxide. And, extensive gas hydrate beds exist on the underwater shelves of the Arctic, as well as in terrestrial arctic permafrost.

The undersea hydrothermal vents that exist at the spreading ridges have been shown through NOAA VENTS Program to be regions of efflux of mass and heat; they have also be shown to be very diverse regions of totally new species of biota. This also applies the cold water seeps that exist in the undersea regions of subduction. Although specific areas (e.g., Juan de Fuca/Gorda Ridge system offshore of Oregon and Washington) have been studied, these are just snapshots of the totality of effects of these systems on a global basis. Such systems are quite extensive in the polar seas. Not only do they affect the global balance of mass and heat, they are also regions of instability that given rise to some of the largest tsunamis.

Objectives: As alluded to under the background, environmental facets of the polar seas are vast. Exploration in that environment would have to be focused and phased in a program that is timely, cost-effective, feasible, and of beneficial to society. Undersea research is expensive. It is particularly expensive in the polar oceans, and a program of exploration would have to be well chosen to maximize the benefits. The effort would have the following objectives:

- Discover new biotic resources, especially those related to deep, cold water fisheries of commercial potential.
- Discover abiotic resources, e.g., gas hydrates, and define the processes that lead to their formation, stability, and sustainability.
- Refine the global implications of vents and seeps that are associated global ocean mass balances of chemicals and heat.
- Discover new extremophiles associated the polar environments, and conduct research on their biotechnical applications to, e.g., new pharmaceuticals.
- Discover changes in the polar oceanic environment that are associated with potential global change.

Scientific and Technical Development: As with the exploration of the farther reaches of space, exploration will depend on the continued use and further development of AUVs and fixed seafloor observatories in the polar ice-covered seas. AUVs need to become more reliable, capable of doing a variety of tasks, and capable of larger range. Fixed, or multi-deployable, seafloor observatories also need to be developed and deployed to examine, *in situ*, new polar scientific discoveries. Larger numbers of ROVs will also be essential. They must have better sensor capability, and be suited for a variety of tasks–from the small ones that can explore smaller crevices to large ones that better equipped for larger payloads. Polar seas exploration will also continue to be dependent upon manned submersibles (e.g., especially of the type as the U.S. Navy's nuclear-powered NR-1)--there is no mistaking the value of the human eye and brain to explore phenomena and resources of the undersea environment, including that of polar seas. Overall success will be dependent upon development of greater sensor capability–e.g., better and smaller electrical, acoustical, and optical sensors. The outcomes of the exploration of the polar seas in the new millennium will be scientific discoveries, never before imagined, that will benefit society and our environmental stewardship of planet Earth.

Outreach and Education: The outreach and education effort in the polar sea exploration is envisioned to utilize the capabilities of Sea Grant, partnerships with the National Geographic Society and the JASON Foundation, and collaboration with interagency efforts concerning the Arctic (e.g., Interagency Arctic Research Policy Committee and the Arctic Research Commission) and international bodies such as the International Arctic Science Committee (IASC) and the Arctic Environmental Protection Strategy (AEPS). Partnerships with similar bodies would also be established for the southern polar areas. Communication efforts will include the development of print media, web sites, radio and television programs which will inform the public about the Federal investment in polar exploration, the highlights of the investments, and benefits to the public.

Budget: In the harsh and remote areas of the polar seas, success scientific exploration will be dependent upon an adequate budget–there is nothing cheap about venturing into this environment. A minimum budget to ensure successes would be on the order of $10M per year.

2002	2003	2004	2005	2006
$10M	$12M	$14M	$16M	$18M